Task K: Hadron Collider Physics with the DØ Detector

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The University of Michigan Task K group continues to make critical contributions to the DØ experiment at Fermilab. Our activities over the past year are in three main areas: detector operation, computing development, and physics analyses. We have been serving many leadership roles in the collaboration, including the coordinations of computing and software project as well as physics analyses. Our group remains to be small, three faculty (Jianming Qian, Homer A. Neal, Bing Zhou), two research physicists (Andrew Alton, Alan Magerkurth) and two students (Jim Degenhardt, Chunhui Han). Both Neal and Zhou have key responsibilities in Michigan Atlas project. In addition, we have benefitted from Jeremy Herr, Qichun Xu, and Zhengguo Zhao. They received the bulk of their support from non-Task K sources. While disappointed by Tevatron's slow delivery of luminosity, it is important for us as experimentalists to maximize physics outputs with the given luminosity. Contrary to many persimistic views, we believe that there are a lot physics to be done. After all, the Tevatron is still the highest energy collider in the world, and the data sample is still expected to be orders of magnitude larger than previous samples.

The operation and calibration of the Central Pre-Shower (CPS) detector has been our main detector effort. We have the insititutional responsibility of the CPS detector that we built. The detector is designed to aid particle identification. Our effort on CPS has evolved during the past year from commissioning to a multi-prong effort to utilize CPS information for physics analyses. This effort spans from gritty-niffty details such as verifying cable and electronic address maps and understanding pedestals, to detector alginment and calibration, and to more high-level physics oriented tasks such as studying electron and photon identifications. The detector mapping was checked using about 40,000 $W \to e\nu$ candidate events. Through this excercise, a few misrouted wave-guide fibers were identified and fixed. Pedestal is another issue took us sometime to understand. While the mean pedestal value is stable over months, variations in its structure with respect to beam-crossing time were observed. These variations have the effect of raising or lowering the readout threshold. Efforts are underway to improve the energy calibration as a result of these variations. On the alignment, a preliminary study indicates the difference between ideal and actual positions is small, at a level of half a millimeter or less. Most of our efforts at integrating the CPS information into physics analyses have been focused on $W \to e\nu$ and $Z \to ee$ decays. The study shows that the CPS provides a factor of four rejection in background while maintaining a 90% efficiency for high p_T electrons from W/Z decays. Several of our collaborators have recently begun investigating photon identification using the CPS information. On the trigger front, the CPS Level-2 trigger firmware passed the simulation and standalone data pump tests, and is currently being commissioned. While a lot remains to be done, we have made dramatic progress in understanding the detector over the past year. We expect to achieve better resolutions with improved alignment and calibration. But even now, the CPS detector has provided effective discrimination between signal and background. This information is current being incorporated into a number of physics analyses .

We have had significant activities in DØ computing. Qian took a Guest Sicentist position with Fermilab Computing Division in the fall of 2002 to be a co-leader of DØ computing/software project, a position he held till February 2003. Our group is instrumental in two major projects: offsite reprocessing and DØ Grid development. Realizing that the computing resources provided by Fermilab are grossly inadequate to meet our physics needs, the collaboration has thus embarked on an ambitious program to integrate resources offsite for Monte Carlo production, data reprocessing, and physics analyses. At Michigan, we are working closely with people from the Center of Advanced Computing (CAC) of our Engineering College to employ their CPU cycles for DØ data reprocessing. CAC is a resource site of the National Partnership for Advanced Computing Infrastructure (NPACI), a program supported by NSF. This reprocessing allows us to take advantage of continued development of our algorithms and will be directly reflected in enhanced quality physics results. The CAC/NPACI will be the first offsite reprocessing site in DØ. In addition, we lead a group of five DØ institutions (Fermilab, Michigan, Michigan State, UC Riverside, UT Arlington) in submitting a medium Information Technology Research proposal to NSF through Michigan to explore the promise of grid computing in high energy physics. The proposed project will establish an international cyber-infrastructure by integrating computing sites in the U.S., Europe and elsewhere, and will advance fundamental science by extending the capability to process, manage, and communicate massive amounts of information on a global scale. Besides our group, other Michgian participants in the proposal are from CAC and the Center for Information Technology Integration.

We also have critical roles in physics analyses. Qian assumed the deputy physics coordinator after steping down from his computing/software post early this year and is scheduled to take over the coordinator job this August. In this position, he has the overall responsibility for collaboration's physics outputs: coordinating all physics analyses, conference presentations as well as publications. His first tasks include reorganizing DØ analysis organization to reduce inefficiency and duplication, recruiting new physics group conveners, reviewing analyses and resources in all physics groups, and encouraging participations by senior collaborators. A new physics organization will be made public at the DØ summer workshop next week. Apart from this leadership role, our analysis effort are currently focused on top quark and electroweak physics. In the top quark physics, we are working on a measurement of top quark production cross section using a recently developed matrix-element method. This novel method extends the widely employed likelihood or neural-network methods to its ultimate limit by using the matrix-elements of signal and background processes as discriminators. For every candidate event, signal and background matrix-elements are calculated. These matrix-elements provide information on how likely an event is a signal and likewise for the background. Monte Carlo studies show that the method provides about a factor of two improvement in statistical power than the traditional methods. We are applying this method in $t\bar{t} \to e +$ jets analysis. Preliminary results are encouraging. Our effort now is to understand its systematic uncertainties. Our interest in electroweak physics is diboson production, specifically we are studying WZ production. This final state is rich in physics. First of all, the production cross section and angular distribution are sensitive to anomalous tripple gauge-boson coupling. Secondly, with $Z \to b\bar{b}$ decays, it's event topology is similar to the light Higgs boson production in association with a W-boson. It thus serves as a benchmark process for Higgs searches at high luminosities. As a first step, we are currently focusing on leptonic decays of W/Z bosons. In addition to these ongoing efforts, we carried out a feasibility study of the multiplicity of the charged particles in jets, aiming to measure fragmentation function $D(z)$ and second binomial moment $R2$ of hadron-hadron correlations. A DØ note is being prepared summarizing this study.

Despite our historically modest level of funding, we have achieved significant accomplishments. We urge DOE to consider adjustments in our support to acknowledge the very significant responsibiltieis we have in the experiment and to allow us to continue training students for the future. Our budget request is focused on personnel along with travel needs. We request the continued support for our Laboratory Services Account at Fermilab. In particular, we request DOE to increase our budget to meet the increased travel needs resulting from PI's role as the next DØ physics coordinator.